Remarks

The Applicants have cancelled Claims 3 and 4 in favor of new Claims 21 and 22. New Claim 21 contains the subject matter of original Claims 1 and 3, while new Claim 22 is the same as Claim 4 except that it depends on new Claim 21. Entry into the official file is respectfully requested.

Claim 1 stands rejected under 35 U.S.C. §112, first paragraph as failing to comply with a written description requirement. The particulars of this rejection are not fully understood inasmuch as the explanation is confusing to the Applicants. However, the Applicants believe that the rejection acknowledges that the claimed "more than 0.40 to 1.1 %" language is supported by the statement that "both endpoints of Si are disclosed in the instant claim 1 and specification but not in same range." The fact is that the Applicants' Specification does support the claimed range. In that regard, Claim 1 originally recited 0.30 to 1.1 %. The new range of more than 0.40 to 1.1 % is inherently supported by the original, broader range.

The rejection also notes in support of the alleged failure to comply with the written description requirement that the newly recited range "is not [sic] preferable range of Si for the instant invention because [sic] point 0.4 % of Si is included in the preferable range of the instant specification." It appears as if there is a fundamental misunderstanding of the requirements of 35 U.S.C. §112, first paragraph. It is not a requirement that specifically claimed subject matter be characterized as "preferred" or be in a "preferable" range. The requirement is that the claimed range is disclosed in the specification. The Applicants have already established that the originally disclosed range of 0.30 to 1.1% inherently supports the new range. Whether the subject matter is "preferred" is utterly irrelevant with respect to §112, first paragraph. On this basis alone, the Applicants respectfully submit that Claim 1 is in compliance with §112, first paragraph.

In any event, the Applicants invite the Examiner's attention to Table 1 of the Applicants' Specification on page 26 wherein Steel No. E has an Si amount of 0.41. This is proximate to the "more than 0.4%" language. Thus, despite the fact that is there no requirement to do so, the Applicants have provided an example that is quite close to the endpoint which is characterized as "more than 0.4%." Although it is possible that there can be amounts of Si that are closer to the endpoint or further away, the fact that Steel No. E is present in the amount of 0.41 clearly provides additional support for that claimed aspect and unequivocally shows that the Applicants were in

possession of the claimed subject matter at the time the Application was filed. Withdrawal of the rejection is respectfully requested.

Claims 1-12 and 17-20 stand rejected under 35 U.S.C. §103 over the combination of US '105 with US '358. The Applicants respectfully submit that the rejection is now moot with respect to cancelled Claims 3 and 4. The Applicants also respectfully submit that even if one skilled in the art were to make the hypothetical combination, such a combination would not result in what the Applicants claim.

The rejection admits that US '358 does not disclose the claimed amount of Si present in an amount of more than 0.4 to 1.1%. The Applicants agree. Nonetheless, the rejection states that the closeness of the ranges renders that range obvious to one skilled in the art. The Applicants respectfully submit that US '358 actually teaches in a very different direction and, accordingly, the claimed range of Si is not obvious.

One of the reasons why the Applicants' newly claimed range is not obvious may be found in the US '358 disclosure in the first paragraph of column 4. US '358 explicitly teaches that:

> ... a silicon content exceeding 0.4% leads to an increase in hardness and consequently deteriorates cold workability. For the above reason, the silicon content should be 0.15 to 0.4%.

These teachings by US '358 are plain on their face and caution those skilled in the art <u>not</u> to increase the amount of silicon because of the deterioration in cold workability. Thus, if one skilled in the art were to venture above 0.4%, one skilled in the art would have a reasonable expectation at an increase beyond 0.4% would result in deleterious effects. Thus, there is no motivation for one skilled in the art to make a hypothetical variation beyond the stated amount. On this basis alone, the Applicants respectfully submit that US '358 taken alone or in combination with US '105 is inapplicable.

However, there are a number of additional reasons.

The task to be achieved by US '358 differs from that of the Applicants. That is to say, the problem to be solved by the Applicants was improving of fatigue strength (dynamic strength) while US '358 sought to improve torsional strength (static rupture strength). Torsional fatigue strength is not improved in many cases, even when torsional strength is improved, and for the improvement of torsional fatigue strength, various types of elements are required.

The Si content plays an extremely important role in the improvement of fatigue strength. Si increases the number of nucleation sites of austenite during induction heating, inhibits grain growth of austenite, and thereby decreases the grain size of the hardened layer. The induction hardened member manufactured by the above-mentioned operation has the prior austenite grain size of 12 μm or less through the thickness of the hardened layer. Furthermore, Si inhibits formation of carbides and therefore prevents a reduction in the grain boundary strength. Si is an element suitable also for the formation of a bainite structure. Thus, Si is an extremely important element which effectively increases the torsional fatigue strength by the three operations mentioned above.

However, when the Si content is 0.40% or less, the prior austenite grain size through the thickness of the hardened layer cannot be decreased to 12 μm or less under any condition for manufacturing a steel product and any induction hardening condition. Hence, high torsional fatigue strength is unable to be obtained. This can be seen from Sample No. 36 in Table 2-2. In Sample No. 36 in Table 2-1, the result of induction hardening effected of steel Y of 0.28% Si, which is tabulated in Table 1, is that the prior austenite grain size of a hardened layer is 15.5 μm. This means that the grain size of 12 μm or less is not obtained. The torsional fatigue strength obtained is of a low value because of this. It is 575 X 10^9 MPa.

Conversely, when the Si content is within the claimed range (more than 0.40%), excellent torsional fatigue strength is obtained. This is shown in Sample No. 14 in Table 2-1. The torsional fatigue test conducted on Steel E which contains 0.41% Si results in an extremely high torsional fatigue strength. It is 870 X 10^5 MPa. That is more than 50% greater than Sample No. 36 and is completely unexpected.

The Applicants' steels are tabulated in the Tables containing Examples 2-1 to 2-3 and Comparative Examples No. 36 and No. 26, both containing Si contents which are out of the chemical range, and are also found in Table 2-1. The relationships between torsional fatigue strength and Si content are represented in a graph in the enclosed Fig. 1. It is understood that excellent torsional fatigue strength is obtained when the Si content is more than 0.4% whereas, when Si content is 0.4% or less, only low torsional strength is obtained.

It can be seen by reference to the Applicants' Specification that the Applicants have achieved a surprising result even in the face of the opposite teachings of US '358. US '358 teaches those skilled in the art not to exceed 0.4%. On the other hand, the Applicants have demonstrated a very

surprising result as illustrated in the enclosed Fig. 1 that the torsional fatigue strength is surprisingly improved by having an Si content of more than 0.4%. The Applicants respectfully submit that one skilled in the art could not have reasonably anticipated this phenomenon based on the teachings of US '358.

The Applicants respectfully submit that hypothetically combining US '105 with US '358 does not solve the deficiencies set forth above. One skilled in the art would again have no reasonable expectation of the surprising result that the Applicants discovered. However, there are additional reasons why US '105 is inapplicable, even if taken in conjunction with US '358.

The technical fields and the tasks to be handled are different between US '105 and the Applicants' steels. That is to say, the Applicants' steels relate to materials for induction hardening and induction hardening members. On the other hand, US '105 relates to carburizing hardening material. Thus, the problems to be solved are completely dissimilar.

The task to be accomplished by the Applicants is to improve torsional fatigue strength while US '105 seeks to improve flaking strength and torsional strength (static fracture strength). As is apparent from the foregoing, US '105 did not conceive the improvement of torsional fatigue strength of an induction hardening steel material and an induction hardened member as was conceived by the Applicants.

Beyond these preliminary differences, the B and Cr contents play an important role in the improvement of torsional fatigue strength. B fosters formation of a bainite or martensite structure in a state before induction hardening. Thus, the prior austenite structure in the hardened layer after induction hardening becomes fine. Consequently, this decreases the grain size of the hardened layer, increases the grain boundary strength and, thus, increases the torsional fatigue strength. Further, a small quantity of B improves the induction hardenability, increases the thickness of a hardened layer and, thus, increases the torsional fatigue strength. Furthermore, B segregates preferentially at the grain boundary and decreases the concentration of P segregated at the grain boundary. This increases the grain boundary strength and torsional fatigue strength. Hence, B is a substantially effective element in improving the torsional fatigue strength.

Cr stabilizes carbides and thus enhances formation of carbides at the grain boundary, decreases the grain boundary strength and, thus, decreases the torsional fatigue strength.

Accordingly, the Cr content is limited to 0.2 mass% or less and is preferably as low as possible. Hence, limiting the Cr content is substantially important in improving the torsional fatigue strength.

The Applicants respectfully submit that the hypothetical combination of US '105 with US '358 would not reasonably lead to the unexpected result discovered by the Applicants with respect to torsional fatigue strength. The Applicants discovered that a 50% or more increase of torsional fatigue strength can be obtained when moving beyond the lower claimed range of more than 0.4% of Si, particularly when considered in combination with the amounts of B and Cr. Withdrawal of the rejection of Claims 1-12 and 17-20 is respectfully requested.

Claims 13-16 stand rejected under 35 U.S.C. §103 over the further hypothetical combination of JP '937 with US '105 and US '358. JP '937 is employed for the proposition that it would be obvious to employ a heating time for the induction heating of 5 seconds or less. The Applicants respectfully submit, however, that even if one skilled in the art were to import these teachings into the teachings of US '358 alone or in combination with US '105, the result from such a combination would still not lead to the Applicants' unexpected result with respect to increases in torsional fatigue strength by employing a silicon content of more than 0.4%. The Applicants have already established this surprising result as shown in the enclosed Fig. 1 relative to the teachings of US '358 which lead those skilled in the art in the opposite direction of what the Applicants claim. Withdrawal of the rejection of Claims 13-16 is also respectfully requested.

In light of the foregoing, the Applicants respectfully submit that the entire Application is now in condition for allowance, which is respectfully requested.

Respectfully submitted,

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